Numerical simulation of two- and three-dimensional gravity-capillary waves

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In nature wind waves of gravity-capillary range are special in many respects. Steep decimeter-range waves develop a characteristic pattern of ‘parasitic’ capillary ripples on their forward slopes. Strong viscous dissipation of centimeter-scale ripples, together with the fact that parameters of parasitic ripples are sensitive to a change in the underlying wave’s steepness, makes decimeter-range waves subject to nonlinear damping. On the other hand, decimeter waves are also subject to strong wind forcing. Understanding the dynamics of gravity-capillary waves is important for remote sensing and for studying long waves generation mechanisms, because momentum transfer from atmosphere to ocean occurs mainly due to the interaction of wind with short waves. We perform numerical simulation of gravity-capillary waves within the framework of fully nonlinear equations of motion (Euler equations) for potential waves using parameterizations for wind forcing and viscous decay. A common approach to modelling two- or three-dimensional potential flows with a free surface is to use boundary integral equation methods, which have high computational costs. Here to take an account of three-dimensional effects we employ a quasi-three-dimensional model put forward by Ruban. It is based on the method of conformal transformations and allows an efficient implementation using a Fast Fourier Transform. The model assumes narrow directional distribution of waves while not imposing any limitations on their steepness. The aim of our work is to model the dynamics of transversely modulated gravity-capillary wavetrains, and to study the effect of capillary ripples on mean wave profiles.